Reverse Ad Hoc on Demand Distance Vector Routing Protocol in MANETs and Performance Comparison with AODV

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***Abstract*— An ad hoc wireless network consists of a set of mobile nodes that are connected by wireless links. The network topology in such a network may keep changing randomly. Routing protocols that find a path to be followed by data packets from source node to a destination node used in traditional wired networks cannot be directly applied in ad hoc wireless networks due to their highly dynamic topology. A variety of routing protocols for ad hoc wireless networks has been proposed in the recent past. AODV (Ad-hoc on-demand Distance vector routing) is a representative among the most widely studied on-demand ad hoc routing protocols. In AODV, source node floods the route request packet in the network to obtain a route for the destination. AODV and most of the on demand ad hoc routing protocols use single route reply along reverse path. Route reply packet may not reach the source node due to rapid changes in topology or link failure resulting in reinitiating route discovery process. This increases communication delay, power consumption & decreases packet delivery ratio. To avoid these problems, the proposed routing protocol generates & maintains multiple route replies. The proposed (modified) AODV protocol is called Reverse AODV (R-AODV). In this paper, R-AODV protocol is implemented using NS-2.35 in Linux platform. Simulations are conducted to evaluate the performance of R-AODV and is compared with AODV using application oriented metrics, such as the throughput, packet delivery ratio and end to end delay. Simulation results show that R-AODV performs well when link breakage is frequent.**

***Index Terms*—AODV, MANETs, NS-2.**

I. Introduction

Mobile ad hoc network [1] is a dynamic network which allows communication between the mobile nodes without a central administrator. The network topology in such a network may keep changing randomly. A variety of routing protocols [2] for ad hoc wireless networks have been proposed in the recent past. Ad hoc wireless network routing protocols [2] can be classified into three major categories based on the routing information update mechanism.

1. *Proactive or table driven routing protocols*:

In this, each node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Routing information is generally flooded in the whole network. Whenever a node needs a route to the destination it runs an appropriate path finding algorithm on the topology information it maintains.

2. *Reactive or on demand routing protocols*:

Such protocols do not maintain the network topology information. They obtain the necessary route when it is required, by using a connection establishment process. Hence these protocols do not exchange routing information periodically.

3. *Hybrid routing protocols*:

These protocols combine the best features of the above two categories. Nodes with a certain distance from the source node concerned or within a particular geographical region are said to be within the routing zone of the given node. For routing within this zone, a table-driven approach is used. For nodes located beyond this zone, an on-demand approach is used.

Focus of study is on-demand routing protocols. One of the on-demand routing protocol is AODV [3]. The main advantage of this protocol is that routes are established on demand i.e., only when it is required by a source node for transmitting data packets. But due to the dynamic change of network topology, links between nodes are not permanent. When a link breaks, a node cannot send packets to the intended next hop node resulting in packet loss. If the lost packet is a route reply packet it brings much more problems as the source node needs to reinitiate route discovery procedure.

The route discovery procedure and design of AODV protocol is discussed by C. Pekin “et al.” in [3]. The design of extended AODV(R-AODV) also called Reverse AODV and the comparative analysis of AODV with R-AODV using UDP traffic for constant bit rate applications considering scalability is discussed by E.Talipov “et al.” in [4].

In this paper the performance comparison of the modified AODV (R-AODV) [4] algorithm in which route reply message is multicast to its neighbors resulting in redundant route reply messages instead of unicasting the route reply to its next hop as in the traditional AODV is done. With this the probability of a successful route discovery is increased as we have repetitious route reply messages in our network.

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The robustness of the R-AODV algorithm is tested and compared with the existing AODV algorithm by using UDP as traffic source.

The rest of the paper is organized as follows: Section II gives a brief introduction of AODV routing protocol and an overview of modified AODV(R-AODV) routing protocol. Simulation setup is described in section III. Section IV gives the results and performance comparison of the two routing protocols. Section V concludes the paper.

II. CLASSIFICATION OF ROUTING PROTOCOLS

a) Ad hoc on demand distance vector (AODV)

Ad hoc on demand distance vector (AODV) [3] routing protocol creates routes on-demand. In AODV, a route is created only when requested by a network connection and information regarding this route is stored only in the routing tables of those nodes that are present in the path of the route. The procedure of route establishment is as follows. Assume that node X wants to set up a connection with node Y. Node X initiates a path discovery process in an effort to establish a route to node Y by broadcasting a Route Request (RREQ) packet to its immediate neighbors. Each RREQ packet is identified through a combination of the transmitting node's IP address and a broadcast ID. The latter is used to identify different RREQ broadcasts by the same node and is incremented for each RREQ broadcast. Furthermore, each RREQ packet carries a sequence number which allows intermediate nodes to reply to route requests only with up-to date route information. Upon reception of an RREQ packet by a node, the information is forwarded to the immediate neighbors of the node and the procedure continues until the RREQ is received either by node Y or by a node that has recently established a route to node Y. If subsequent copies of the same RREQ are received by a node, these are discarded. When a node forwards a RREQ packet to its neighbors, it records in its routing table the address of the neighbor node where the first copy of the RREQ was received. This helps the nodes to establish a reverse path, which will be used to carry the response to the RREQ. AODV supports only the use of symmetric links. A timer starts running when the route is not used. If the timer exceeds the value of the 'lifetime', then the route entry is deleted.

Routes may change due to the movement of a node within the path of the route. In such a case, the upstream neighbor of this node generates a 'link failure notification message' which notifies about the deletion of the part of the route and forwards this to its upstream neighbor. The procedure continues until the source node is notified about the deletion of the route part caused by the movement of the node. Upon reception of the 'link failure notification message' the source node can initiate discovery of a route to the destination node.

b) Modified AODV (R-AODV)

Most of on-demand routing protocols, except multipath routing uses single route reply along the first reverse path to establish routing path. In high mobility, pre-decided reverse path can be disconnected and route reply message from destination to source can be missed. In this case, source node needs to retransmit route request message. AODV protocol uses a single route reply message which may be lost in a network with mobile nodes. Transmission control protocols uses acknowledgements to confirm successful data transmission. When TCP is used as a transport layer protocol in MANET which employs AODV at network layer, it deteriorates the performance of the network when mobility is high. The main purpose of study is to increase the possibility of establishing routing path with less RREQ messages than the other protocol has, when topology changes by nodes mobility.

The modified AODV (R-AODV) [4] protocol discovers routes on-demand using a reverse route discovery procedure. During route discovery procedure source node and destination node plays some role from the point of sending control messages. Thus after receiving RREQ message, destination node floods reverse request (R-RREQ), to find source node. When source node receives an R-RREQ message, data packet transmission is started immediately.

III. SIMULATION SETUP

The R-AODV [4] protocol incorporates a route reply similar to route request in AODV [3]. To verify the hypothesis, R-AODV is implemented by changing the source code of AODV in NS2 simulator [5] to enable multiple route reply packets. The simulation setup is described in Table I.

PARAMETER	VALUE
PLATFORM	UBUNTU 11.10
NS VERSION	NS- 2.35
NO. OF NODES	10
SIMULATION TERRAIN SIZE	500 M X 400 M
SIMULATION TIME	80 SECONDS
APPLICATION LAYER	CBR
TRAFFIC SOURCE	UDP

Table I. Simulation parameters

Validation module is build by constructing a scenario of 10 mobile nodes using TCL script. The awk script is run on the trace file obtained after the simulation in Linux Kernel to obtain the statistics of throughput, delay and packet delivery ratio. Comparison between AODV and R-AODV is made under UDP considering the extracted statistics.

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a). Performance Metrics:

- Throughput: Throughput is the total of all packets successfully delivered to destination over total-time and result is found as Kbps.
- Average End-to-End Delay: Indicates how long it took for a packet to travel from the source to the application layer of the destination. Calculated in ms.
- Packet Delivery Ratio (PDR)/Packet Delivery Fraction (PDF): Is the ratio of the number of packets successfully received by all destinations to the total number of packets injected into the network by all sources. This is calculated in terms of percentage.

IV. Simulation Results

In this section a comparative analysis of the performance metrics of both the on demand routing protocols AODV and R-AODV with UDP as the traffic source for 10 mobile nodes is done. Simulations are performed for five times and the average value is calculated in order to achieve accurate results as in mobile ad hoc networks, mobile nodes keep on moving at various times.

Figure 1. shows NAM window with data transfer among two source-destination pairs 0-9 & 1-8.

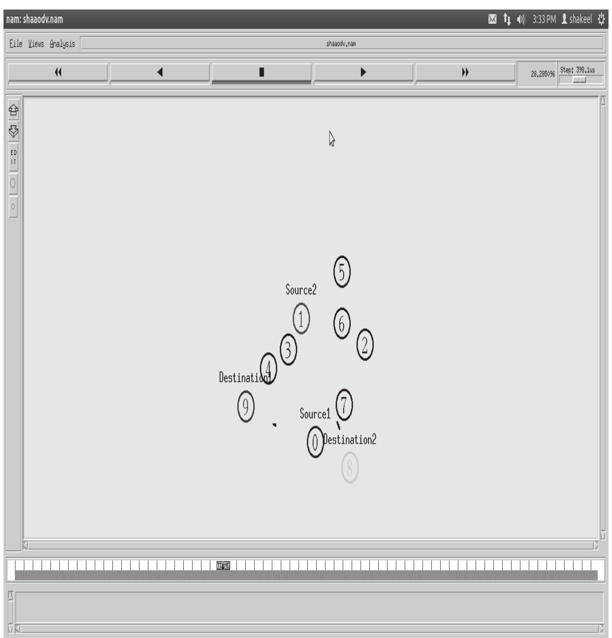

Figure 1.Screenshot of data transfer

Figure 2. shows throughput obtained for AODV and R-AODV routing protocols for a 10 node network. From figure it is clear that R-AODV gives better throughput performance compared to AODV protocol.

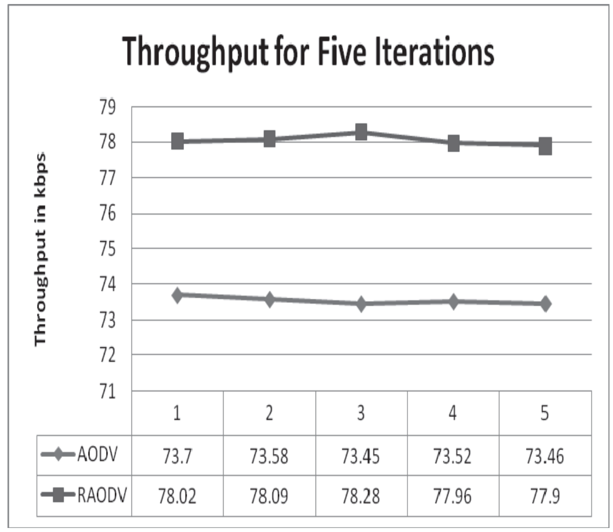

Figure 2. Throughput comparison graph of AODV & R-AODV

End to end delay is more for AODV compared to R-AODV as shown in figure 3. This is due to the fact that route discovery in AODV consumes more time compared to R-AODV and may be reinitiated more number of times.

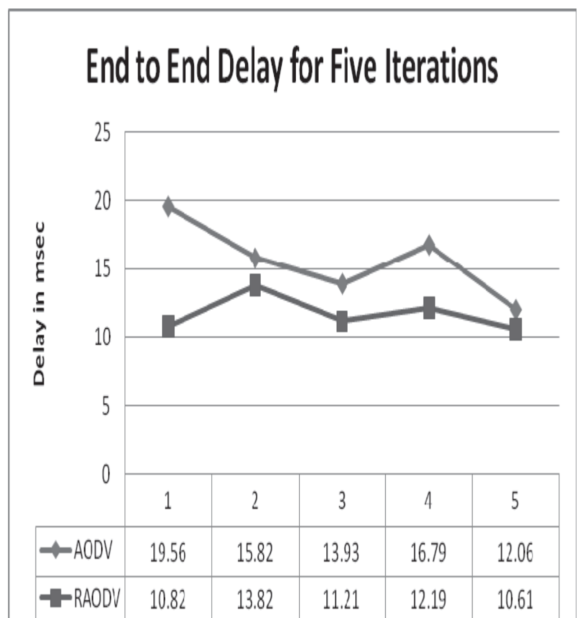

Figure 3. End to end delay comparison graph of AODV & R-AODV

Figure 4. shows the packet delivery ratio obtained for AODV and R-AODV. From figure it is clear that when an average value is considered then packet delivery ratio is approximately same for both routing protocols.

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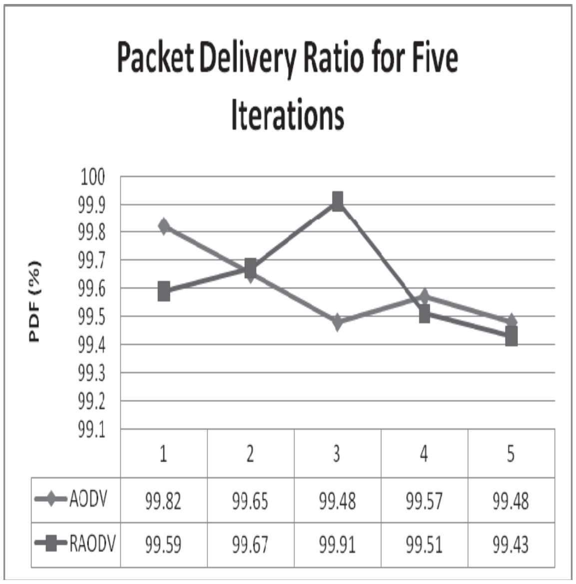

Figure 4. Packet delivery ratio comparison graph of AODV & R-AODV

Table II. Shows the average values of throughput, end to end delay and packet delivery ratio, calculated after five iterations.

No of Executions	Throughput in Kbps		End to End delay in msec		Packet delivery ratio in %	
	AODV	**RAODV**	**AODV**	**RAODV**	**AODV**	**RAODV**
1	73.70	78.02	19.56	10.82	99.82	99.59
2	73.58	78.09	15.82	13.82	99.65	99.67
3	73.45	78.28	13.93	11.21	99.48	99.91
4	73.52	77.96	16.79	12.19	99.57	99.51
5	73.46	77.90	12.06	10.61	99.48	99.43
AVG	73.54	**78.05**	15.63	**11.73**	99.60	**99.62**

Table II. Average values

CONCLUSION

Successful delivery of route reply message is very important in a MANET as a lot of route discovery effort is wasted if a reply message is lost, moreover a new route discovery process has to be reinitiated. In the proposed R-AODV protocol frequent route discovery is avoided due to multiple route reply messages resulting in less routing overhead. Thus, from simulation results R-AODV protocol has better throughput and average end to end delay. Further multiple route reply messages in MANET results in approximately same packet delivery ratio.

In this paper the two on-demand routing protocols AODV & R-AODV are analyzed and their performances have been evaluated with respect to three performance metrics using UDP as the traffic source. This paper can be enhanced by analyzing other MANET routing protocols with different traffic sources.

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